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Instruction Manual

for

Model 809

Phase Generator/Meter

RFL Industries, Inc.
A Dowty Group Company

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Instruction Manual

for

Model 809

Phase Generator/Meter

Book 95700
8/82

Warranty

The Model 809 Phase Generator/Meter is warranted for 12 months from date of delivery for replacement of any part which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f.o.b. Boonton, N. J.

RFL Industries, Inc.
A Dowty Group Company
Boonton, New Jersey, U.S.A.

WARNING:

The Equipment Herein Described Contains High Voltage

Exercise due care during operation and servicing.
Read safety summary on reverse of this page.

SAFETY SUMMARY

The following safety precautions must be observed at all times during operation, service, and repair of this product. Failure to comply with these precautions, or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. RFL assumes no liability for failure to comply with these requirements.

GROUND THE CHASSIS

To minimize shock hazard and to allow the equipment to perform optimally, the chassis and cabinet must be connected to an electrical ground. All equipment is provided with a ground terminal on the rear, or with a three-connector ac power cable. The ground terminal must be connected to an electrical ground by suitable cabling. For its location refer to the wiring diagram for the chassis or cabinet. The power cable must be plugged into an approved three-contact electrical outlet.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the product in the presence of flammable gases or fumes. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

DO NOT OPERATE IN WET OR DAMP AREAS

Do not operate the product in wet or damp areas. Operation of any electrical equipment in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove covers. Replacement of components and internal adjustments must be made by qualified maintenance persons. Disconnect power cable when replacing components. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries always disconnect power and discharge circuits by grounding before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person capable of rendering first aid and resuscitation is present.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform an unauthorized modification to the equipment. The product may be returned to RFL for service and repair to ensure that safety features are maintained.

DANGEROUS-PROCEDURE WARNINGS

Throughout this manual, warnings identify potentially dangerous procedures. Instructions contained therein must be followed.

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RFL Model 809 Phase Generator/Meter.

DESCRIPTION

The Model 809 is a dual-purpose instrument designed to function (a) as a phasemeter for measuring the phase angle between a voltage and current applied to a load and (b) as a generator of two output voltages whose relative phase is determined by the operator. The range of phase measurement, or displacement, is from 0 to ±180° in four overlapping quadrants. The indicator is a 3-½-digit display, and the resolution is 0.1°.

The instrument is especially useful for calibrating wattmeters, phase-angle meters, and power-factor meters when used with a current and voltage source such as a pair of RFL Model 829G's, Model 828's, or one of each. Other current and voltage sources can be used, providing they have appropriate provision for low-level input signals which will control the phase of their output.

The voltage input is isolated from the metal enclosure, which is connected directly to the third (ground) terminal of the power cord. The low side of the voltage input is connected to circuit common, and it may be connected to the enclosure if desired. The current input is a tapped current transformer completely isolated from all other circuits.

Warmup time for full accuracy is only several minutes. Response to a change of input signal is essentially instantaneous.

Top and bottom covers are each released by removing just two screws. This provides easy access to both sides of the circuit board for repair and routine maintenance. Test points are mounted on the board at strategic points in the circuit to facilitate analysis and repair.

The power supply has been designed so that the instrument will operate from nearly all commercial power sources throughout the world. A switch is provided to select either one of the two, wide, input-voltage ranges.

PRINCIPLES OF OPERATION

The organization of the circuits of the Model 809 is shown in Figure 1. The circuits fall into two major groups: those used for generation of a variable-phase output signal, and those used for measuring the phase difference between two input signals. These two circuits provide for the instrument's major function, that is, as a wattmeter calibrator. This is discussed in the section titled Operation.

In the phase-generator section, a state-variable oscillator either generates the output at one of four preset frequencies, or it is reconfigured to filter a line-frequency signal from the local powerline. In either event, three outputs are provided by the oscillator circuit, each of fixed phase with respect to a fourth, reference output. The quadrant of the relative phase difference between the two output signals is selected with a quadrant-selector switch, and the phase within the selected quadrant is set with the phase control on the front panel. After automatic gain control to stabilize output amplitude, the two signals appear at the output connector.

Because the major function of the instrument is wattmeter calibration, the phasemeter section has different inputs for current and voltage, so that a current shunt is not required. A low-loss, accurate current transformer senses the current, and a high-impedance voltmeter input senses the voltage. Each input signal is squared and then combined in a circuit whose squarewave duty cycle is a direct function of the phase difference between the two input signals. This signal then modulates an accurate dc reference voltage either on or off, so that after filtering the average value of that signal is directly proportional to phase difference of the two inputs. A digital voltmeter, calibrated to read degrees of phase shift, measures and indicates that voltage.

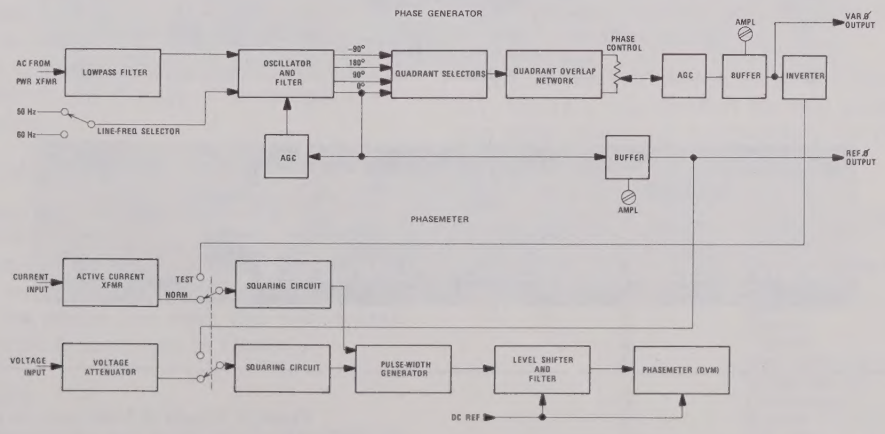


Figure 1. Block diagram of circuits, Model 809.

SPECIFICATIONS

AS A PHASEMETER

Voltage Input

Three full-scale ranges of 10, 100, and 1000 volts, each of which has a dynamic range from 12 to 120% of full scale. Burden is 1000 ohms per volt.

Current Input

Three full-scale ranges of 1, 10, and 50 amperes, each of which has a dynamic range from 12 to 120% of full scale. Burdens at 60 Hz are 0.25, 0.1, and 0.07 volt for the 1, 10, and 50 ampere ranges, respectively.

Accuracy

±0.5° from 50 to 450 Hz; ±1.0 ° from 451 to 1000 Hz, 50-A range unspecified above 450 Hz.

AS A PHASE GENERATOR

Output Frequency

Internally generated, front-panel selected frequencies of 50, 60, 400, and 1000 Hz. Either the 50-Hz or the 60-Hz signal is synchronized to the powerline, depending upon line frequency. Unsynchronized accuracy is ±1%.

Output Level

Amplitude stabilized and adjustable from 0 to 5 volts ±10%. 10 mA maximum current.

Stability

24 hours ±0.25% of setting
90 days ±1.0% of setting

Total Harmonic Distortion

Equal to or less than 0.15%.

Phase-Shift Range and Control

0 to ±180° in four, overlapping, selectable quadrants. Control resolution is approximately 0.01°.

GENERAL CHARACTERISTICS

Ambient Temperature Operating Range

For rated accuracy: 18 to 28°C. May be operated from 0 to 18°C and from 28 to 50°C at a derated accuracy specification of ±0.05°/°C.

Primary Power

Either 90-125 or 180-250 Vac, 48-62 Hz, approx. 16 VA.

Dimensions and Weight

The instrument is enclosed in a relay-rack style cabinet 19 inches wide, 3.5 inches high, and 10 inches deep (483 x 88.9 x 254 mm). The weight is 7.5 lbs (3.4 kg).

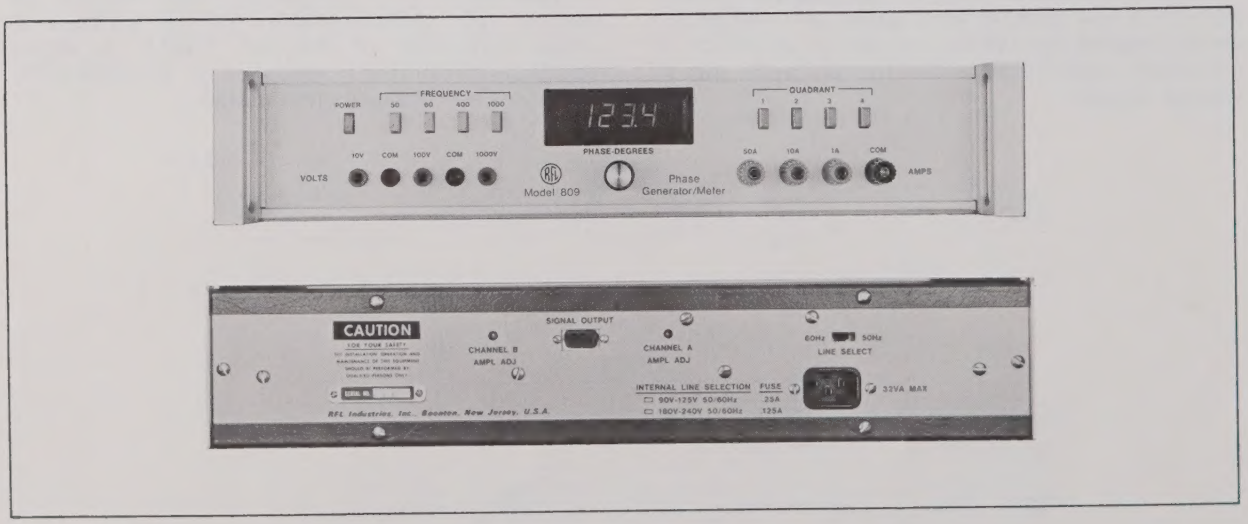


Figure 2. Details of front and rear panels, Model 809.

OPERATING INSTRUCTIONS

FUNCTIONS OF CONTROLS

Figure 2 shows front and back panels of the instrument, on both of which controls and signal connections will be found.

Signal Connections

Input voltage and current are connected to the terminals shown on the front panel in Figure 2. Permissible signal levels are between 12 and 120 percent of the range indicated on each input terminal. Use of too high a range will degrade resolution and accuracy. Use of too low a range may introduce errors caused by saturation of the circuits. Note that ground terminals in the voltage group are duplicated to permit using the standard ¾-inch-spaced bananna plug. Current binding posts should be tightened firmly to minimize contact resistance.

Output voltages are present at the output jack shown at the center of the back panel illustrated in the lower part of Figure 2. Their stabilized output level is set, at any value between zero and five Vrms, with the screwdriver-operated controls on the back panel.

Operating Controls

The power switch is a push-push type. One push turns power on. A second push turns power off. The digital indicator serves as a pilot to indicate when power is on.

The frequency of the output signals is selected by pressing the desired one of four front-panel pushbuttons.

Phase difference of the output signals is selected by first pressing the button designating the desired quadrant, and then rotating the PHASE-DEGREES knob until the desired indication appears on the display. Quadrant numbering is according to the usual trigonometric sense.

When used as a phasemeter, no controls need be used. When input voltage and current are within their prescribed levels, as described in the foregoing, the phase angle is indicated automatically and the quadrant is implicit in the display. The voltage channel is the reference.

Phase Angle of Output

When the phase difference of output signals is of interest (as distinct from input signals) a NORM-TEST switch, located on the circuit board inside the chassis, may be set to TEST. The display will then indicate the relative phase between the two output signals. This switch is identified in Figure 7.

INSTALLATION

Individual instruments are shipped in commercial packing cartons, one per carton. Take care when opening to ensure that the instrument is not damaged or scratched. Examine all packing material carefully, so that items of value are not discarded. To prepare the Model 809 for operation, the following steps should be used:

(1) Examine the rear panel of the instrument, Figure 6, and set the slide switch to the position corresponding to the frequency of the local power source.

(2) Check the table at the lower right of the rear panel. One of the rectangles will be marked to designate the line voltage and fuse combination set up when the instrument left the factory. If the markings agree with the supply voltage to be used, proceed to Step (4). If not, the procedure given in Step (3) should be followed.

CAUTION

Hazardous voltages can be present inside the chassis. Only authorized persons should work within the instrument. Be sure to read and understand the safety notice on Pages iii and iv of this manual.

(3) To change the fuse and position of the line-voltage switch, first remove the top cover by removing the two binder-head screws securing it to the rear panel. Slide the cover back and off the instrument. The fuse and switch can be located with the aid of Figure 7. Set the switch to the desired line-voltage range and install a fuse of correct rating. Fuses should be slo-blo Size 3AG. A rating of 0.25 ampere is used for the low-voltage range. A 0.125-ampere fuse should be used for the high-voltage range. Check that the NORM-TEST switch has not been accidentally moved from its NORM position. Replace cover.

(4) If instrument is to be relay-rack mounted, this is a convenient point in the procedure for doing so.

(5) Plug power cord into rear-panel receptacle and then into an appropriate and properly grounded source.

(6) Output signals are taken from the output jack, J1, Figure 2, centered in the rear panel. The following table shows pin connections for the output jack J1:

SIGNALS ON J1

Pin Number	Function
1	Ref-voltage Output-Channel A
2	Spare
3	Spare
4	Spare
5	Var-phase Output-Channel B
6	Common
7	Spare
8	Spare
9	Common

(7) Restore power, if necessary. The instrument may now be used for its intended purpose as described below in the following paragraphs.

Model 809 with Model 828

For use with an RFL Model 828, the Model 809 amplitude adjust on Channel A and/or Channel B must be set for a voltage output of 3 ±0.5 Vrms for proper operation of the Model 828.

Model 809 with Model 829G

For use with an RFL Model 829G, the Model 809 amplitude adjust on Channel A and/or Channel B must be set for a voltage output of 2 ±0.1 Vrms for proper operation of the Model 829G.

Model 809 with Models 828/829G

If a combination of one Model 828 and one Model 829G is used in conjunction with the Model 809 the appropriate output Channel adjust must be set for the correct output level as detailed above.

Interconnecting Cables

The following cables are supplied with each instrument:

(1) One cable, part number 96254, with three 9-pin male cable connectors, is supplied. The cable labeled A carries the reference phase, and the cable labeled B carries the variable-phase output. This cable may be used to connect the Model 809 to two RFL Model 828 calibrated sources.

(2) Two identical cables, part number 96255, are supplied, each with a telephone plug on one end and a 9-pin female cable connector on the other. The cable connectors mate with the cable described in the foregoing paragraph, and they provide for connection of the Model 809 with two Model 829G calibrated sources. The combination of one Model 828 and one Model 829G is accomplished by using just one of the second cables.

The reference-phase output, Phase A, of the Model 809 is usually connected to the calibrator providing voltage to the device under test, while the variable-phase output, Phase B, is connected to control the current input of the device under test.

CAUTION

Input leads to the Model 809 can have potentials as high as 3000 volts peak-to-peak.

Because high voltages are hazardous, operators are cautioned to make connections only when the circuit under test is de-energized, at which time connections should be made correctly, firmly, and tightly to preclude any subsequent need for touching them.

OPERATION

As a Phasemeter

Used as a phasemeter, the Model 809 is connected as shown in Figure 3. The source may be of any frequency from 50 to 1000 Hz. Voltage and current inputs should be connected to the proper full-scale ranges. The reference phase is the voltage channel. The quadrant of the unknown phase difference is implicit in the polarity and magnitude shown on the display, and the quadrant selectors are not used.

In this mode, the instrument is useful for measuring phase angle in single-phase and polyphase power systems, for measuring phase angle to determine the efficiency of motors, transformers, and other reactive loads, and for identifying unbalanced, reactive loads in polyphase systems.

As a Generator

The Model 809 is especially useful for calibrating phase-angle and power-factor meters, and for determining the phase sensitivity of wattmeters. For these applications, the instrument is used to control the phase of the output voltage and current of a pair of calibrated sources, providing they have appropriate means for low-level signal input, such as found in the RFL Models 828 and 829G.

The arrangement is shown in Figure 4. The reference phase is chosen as the voltage signal. The phase of the current source may be set at any angle with respect to the reference by selecting the desired quadrant and then rotating the control knob on the front panel until the desired angle is shown on the digital indicator.

The voltage and current inputs of the Model 809 are connected directly to the voltage and current inputs of the device under test, to ensure that the proper phase difference appears at these points. The output signals from the Model 809 may have the same phase, but they likely will not because of phase shifts inherent in the voltage and current sources. These also may vary with signal frequency. The system shown, however, is self compensating and ensures that the device under test is tested as desired. A TEST switch, mounted internally on the circuit board, provides for reading relative phase of the output signals, if desired.

Sources of Apparent Error

When the Model 809 is used as a generator for input signals to two calibrated sources while it simultaneously measures the relative phase of input signals to a device under test, as in Figure 4, there is always a possibility that the phase indicated by the phasemeter may be different from that expected from the settings used for the quadrant switch and the phase-angle-control knob. The most common case is that in which the phase measured is 180° different from that called for. For example, if an operator were to call for an angle in Quadrant 1, the phase meter may indicate an angle 180° away, in Quadrant 3.

It is essential to bear in mind that between the phase-controlled outputs of the Model 809 and its two phase-measuring inputs there are interposed at least two signal sources and some cables, as well as a set of wires interconnecting the signal source, the device under test, and the phasemeter. It must be recognized that the phasemeter section of the Model 809 always measures whatever phase difference appears at its input terminals, and that it shows not only the proper angle but also the proper quadrant. With this in mind, the following possibilities should be considered:

(a) An inadvertent inversion of voltage or current between one or more units through failure to observe the requisite distinction between high and low terminals. The solution is simply to correct the error. Note that, especially on the voltage side, such an error carries with it the possibility of placing metal cabinets or chassis at hazardous potentials with respect to each other.

(b) Inadvertent exchange of Cables A and B at the output of the Model 809. This would cause the reference phase to be read as the relative phase. The solution is simply to correct the error.

(c) When operating near the edge of any quadrant, that is, near 0°, 90°, ±180°, and −90°, it is possible that the phase delay through a calibrated source may be great enough to move the output signal to an adjacent quadrant. The operator will then observe that the quadrant of the output signal indicated on the phasemeter is different from that selected. The solution for this is simply to select another quadrant for the output signal from the Model 809 so that, after delay through the calibrated source, the output, as shown on the phasemeter, is of the desired phase. Because the Model 809 operates with overlapping quadrants, so that every angle can be displayed without gaps, the need for this solution is relatively remote.

When operating with phase differences of 180 ±0.1°, there is a possibility that the display may appear to be unstable. The apparent trouble is caused by the digital circuits, is normal, and can be avoided by reversing the leads to the current input and adding 180° to the reading thus obtained.

(d) A phase inversion may exist in one of the calibrated sources. The circuits of the Model 809 are arranged on the assumption that its output signal to the calibrated source suffers insignificant phase shift in its passage through that generator. But there is no reason to assume that every calibrated source has no phase inversion or, even, that its output phase in the voltage mode is the same as its output phase in the current mode. Generally, it may be assumed that in the RFL Model 829G calibrated source there is no significant phase shift in the voltage mode and that there is a 180° shift between input and output when it is used in the current mode. Two solutions for correcting this inversion are possible:

(1) Providing the output of the calibrated source is isolated from ground, the polarity of connection to it is simply reversed. This is possible with the RFL Model 829G, providing that the connecting link between the low side of the output and the chassis is removed.

(2) The polarity of connections may be left unchanged, in which case the operator simply selects a quadrant 180° away from that desired. Thus, by reversing the phase of the input signal, the phase reversal within the source is cancelled.

Precautions for High Currents

When measuring with high currents, it is important that all current connections be made firmly, that heavy, short leads be used for carrying the current, and that the voltage-sensing leads be dressed well away from the current-carrying conductors. This is especially important when operating at the highest ranges for current and for frequency.

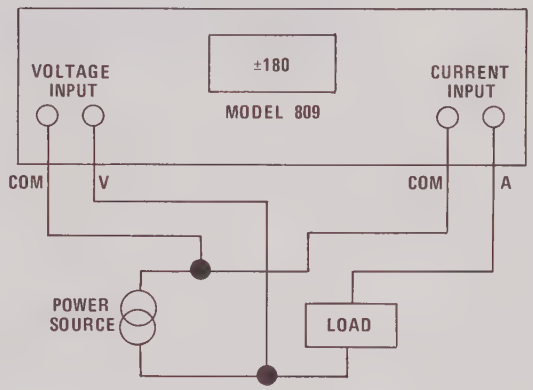


Figure 3. Connections for use of the Model 809 as a direct-reading phasemeter.

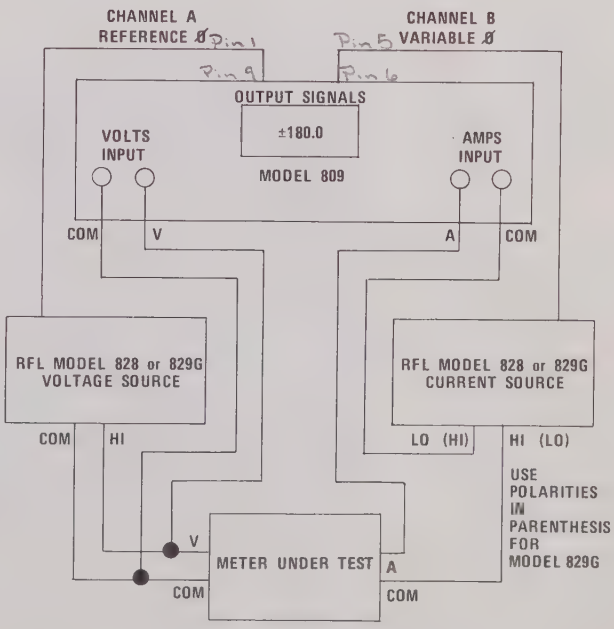


Figure 4. Connections for use of the Model 809 as a combined measuring device and control-signal source for testing wattmeters, varmeters, power-factor meters, and phasemeters.

CAUTION

When top or bottom covers of this instrument are removed, as for calibration or repair, hazardous voltages are exposed. During such operation, the safety precautions outlined on pages iii and iv of this manual must be followed at all times.

CALIBRATION

The following procedure may be used for calibrating the Model 809:

Equipment Required

(a) An oscilloscope such as the Tektronix Model 546, or equal.

(b) A frequency counter and time-interval meter.

(c) A distortion analyzer such as the Hewlett-Packard Model 331A, or equal.

(d) A phase-angle standard with an accuracy of at least 0.05°.

(e) Non-inductive current shunts capable of carrying 1, 5, and 50 amperes without overheating, and with the minimum resistance needed to provide an adequate input signal to the phase-angle standard selected.

(f) An ac-dc digital multimeter (DVM) with a full-scale sensitivity range of approximately 10 mV, such as the Fluke Model 887.

(g) Two RFL Model 829G calibrated signal sources. If preferred, an RFL Model 828 may be substituted for the voltage source.

(h) RFL Model HB-21975 Current Transformer.

Setup

For calibration (not repair) only the top cover need be removed from the instrument.

Calibration Procedure

(1) Set S10, Figure 7, to the proper powerline voltage and F1 to the proper value as described under Installation. The instrument should be warmed up, with power on and the top loosely covered, for about 15 minutes.

(2) Set S12, Figure 7, to NORM.

(3) Push in either the 50- or the 60-Hz frequency selector. Be certain to use the one different from the powerline frequency in use.

(4) Select Quadrant 1 (S6).

(5) With the oscilloscope, monitor the reference-voltage output at J1-1, Figure 6, or at IC2, Pin 6.

(6) Adjust R21, CHAN B AMPL ADJ, to reduce the output voltage to its minimum.

(7) Adjust R22, OFFSET 1, to obtain zero ± 2 mVdc at the output, while using the most sensitive range on the oscilloscope.

(8) Readjust R21 for an output of approximately 7 volts peak-to-peak (3 Vrms).

(9) Reconnect the oscilloscope to monitor the variable-phase output, either at J1-5 or at IC8-6.

(10) Adjust R47, CHAN A AMPL ADJ, to reduce the variable-phase output voltage to minimum.

(11) Adjust R46, OFFSET 2, to produce zero ±2 mVdc on the most sensitive range of the oscilloscope.

(12) Readjust R47 for an output of approximately 7 volts peak-to-peak, (3 Vrms).

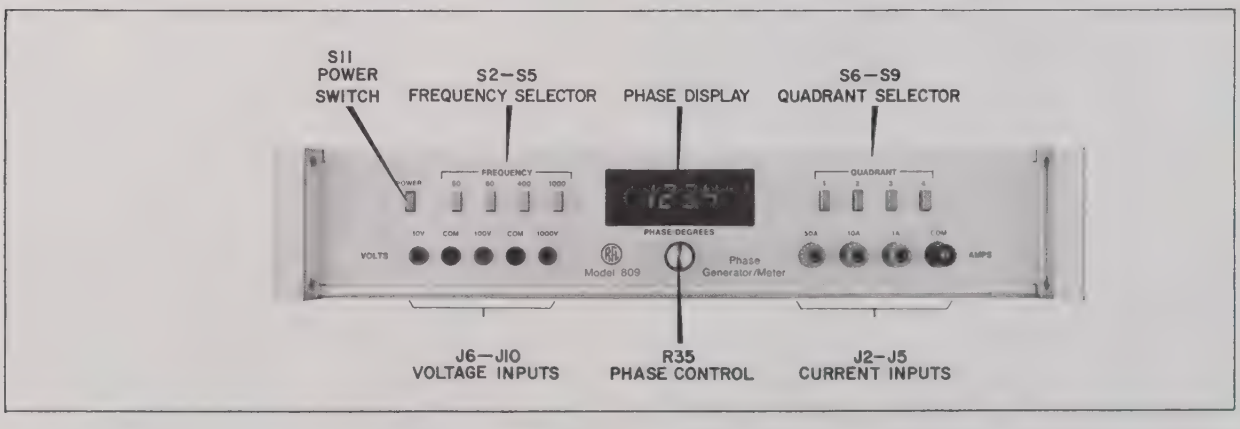


Figure 5. Identification of front-panel components, Model 809.

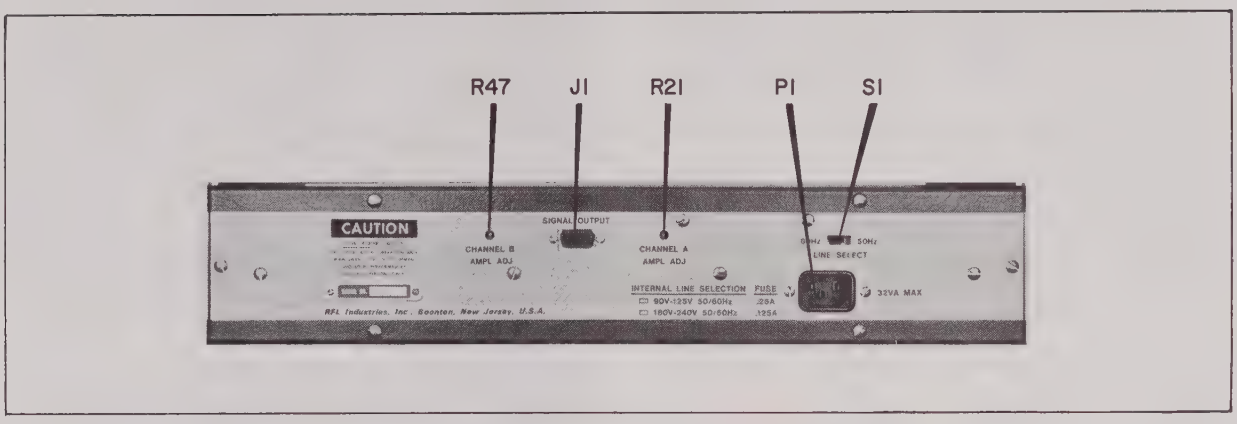


Figure 6. Identification of rear-panel components, Model 809.

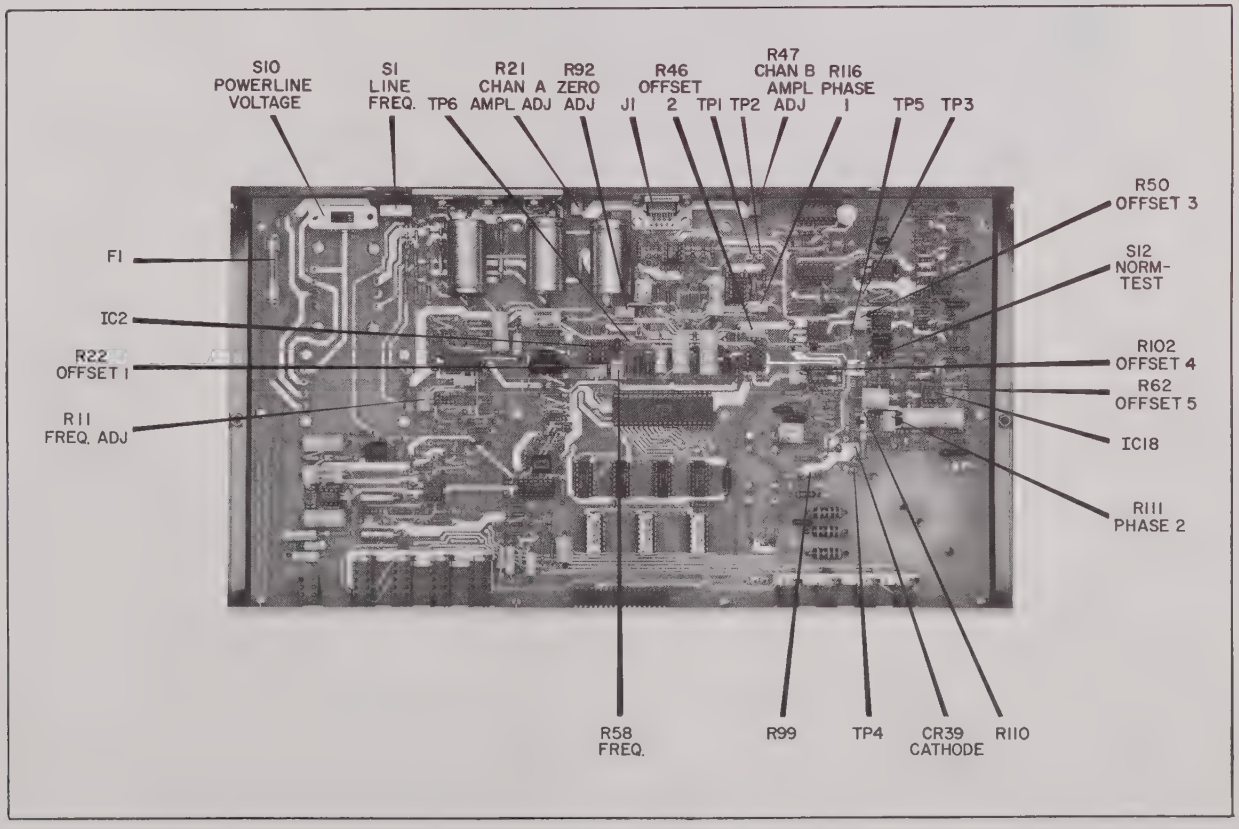


Figure 7. Locations of test points and adjustments, Model 809.

(13) Measure frequency or period at either output of J1 and adjust R11, FREQ ADJ, until the counter measures the frequency selected at the front panel, ±0.1%. A period measurement will give the required resolution.

(14) Change the selected frequency to the power-line frequency.

(15) With a clip lead, short-circuit R110 and R99, then adjust R50, OFFSET 3, for a voltage of zero ±1 mVdc at TP3. Ground meter at the cathode (ground) end of CR39.

(16) Adjust R102, OFFSET 4, for a voltage of zero ±1 mVdc at TP5. Ground meter at the cathode (ground) end of CR39.

(17) Remove clip lead.

(18) Some units of the Model 809 may contain R62, OFFSET 5. When it is present, adjust R62 for a voltage of zero ±1 mVdc at junction of R68 and R69.

(19) Move S12, NORM-TEST, to the TEST position, and connect the phase-angle standard to J1-1 and J1-5; measure the phase difference of the two outputs. J1-1 carries the reference phase. Ground meter at J1-6 or J1-9.

(20) Select Quadrant 1 and rotate R35, the phase-angle control on the front panel, until the standard indicates 0 ±0.02°.

(21) Adjust R92, ZERO ADJ, to produce a readout of zero on the digital display of the Model 809.

(22) Monitor TP6 with the frequency counter and adjust R58, FREQ 2, to read 40 kHz ±0.1% (39.96 to 40.04 kHz).

(23) Select Quadrant 2 and adjust R35 to cause the phase-angle standard to read 160.0 ±0.02°.

(24) While observing the digital indicator, adjust R116, PHASE 1, until it indicates 160.0°.

(25) Repeat Steps (20 through 24).

(26) Set S12 to NORM, and select an output signal of 400 Hz (S4).

(27) Set up the test circuit shown in Figure 8. Set voltage to 10 Vac, current to 1 Aac, and adjust R111, PHASE 2, until the indicators of the standard and of the Model 809 agree within ±0.1°.

(28) Check operation of the circuit with the following procedure:

(a) Set output to the voltage channel to 10 volts. Leave current output at 1.0 ampere.

(b) On Model 809, move voltage input to 100-V range, current input to 10A range.

(c) The Model 809 should read the same as observed at Step (22) within ±2°.

(d) Without changing the current and voltage sources, move them to the 1000-V and 50-V ranges of the Model 809. The phase indication should be within ±20° of that noted at Step (27).

(e) Adjust Model 809 for 400-Hz output. Adjust voltage source for 100-v output and connect to 1000-V range of Model 809. Connect reference input of phase-angle standard to voltage input of Model 809. Connect other input of phase-angle standard to TP4, Figure 7, and note the phase-angle difference, if any. Using the method of successive approximation, add a trimmer capacitor at Position C59 to bring the phase-angle difference to ±0.05°. The trimmer capacitor should be in the range between 0 and 30 pF.

(30) Using a 10-volt input signal and the 100-volt range, select a value for C57, between 0 and 30 pF, as outlined in Step (29), for the 1000-V range.

(31) Using a 1-volt input signal and the 10-volt range, select a value for C58, between 0 and 30 pF, as outlined in Step (29), for the 1000-volt range.

(32) Using the circuit given in Figure 8, check that the Model 809 is within specification at 0, 30, 90, 120, 150, -150, -120, -90, and -30°.

(33) Repeat Step (32) at output frequencies of 50, 60, and 1000 Hz.

(34) Set up the test equipment according to Figure 9. Then check the Model 809 for conformance to specification at 0, 30, 90, 120, 150, -150, -120, -90, and -30°.

(35) Repeat Step (34) at output frequencies of 50, 60, 400, and 1000 Hz.

(36) Set up the test equipment according to Figure 10. Then check the Model 809 for conformance to specification at 0, 30, 90, 120, 150, -150, -120, -90, and -30°.

(37) Repeat Step (36) at output frequencies of 50, 60, 400, and 1000 Hz.

(38) Connect a 10X attenuator-type oscilloscope probe to the junction of R5 and C3. This is also the non-inverting input, Pin 3, of IC1A. Connect a distortion analyzer at J1-1 and select an output frequency of 60 Hz.

(39) Measure distortion of the output signal at J1-1. It should be 0.1%, or less. If not, connect a capacitor decade at Position C28 in the circuit, and adjust it for an output-signal level of 17 to 20 Vac peak-to-peak (7-9 Vrms). Install a capacitor of the indicated value, probably near 1500 pF, and check the distortion, which should be within specification.

(40) Synchronize the oscilloscope to the powerline frequency and connect its vertical input to J1-1. Check that the output signal is, in fact, synchronized to the powerline by synchronizing the oscilloscope externally to the powerline. Move S1 to the alternate frequency and confirm that the output signal is now not synchronized. Return S1 to the position corresponding to the powerline frequency.

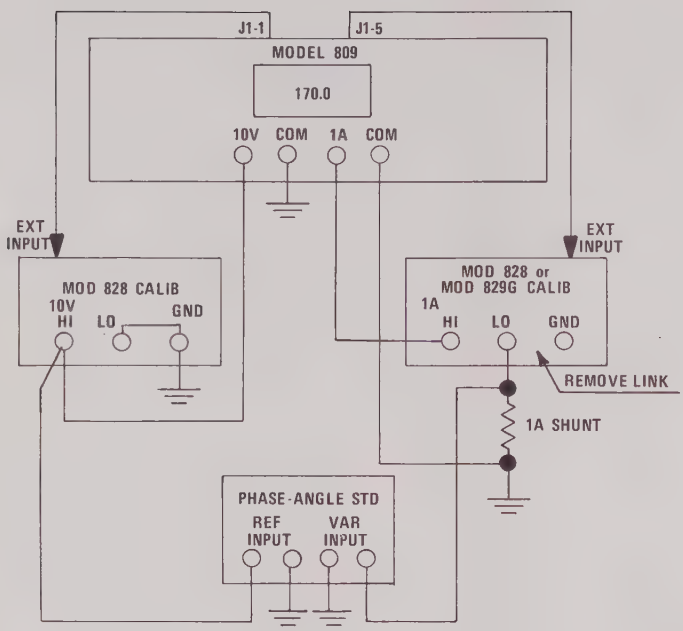


Figure 8. Test circuit for adjustment of R111, PHASE 2.

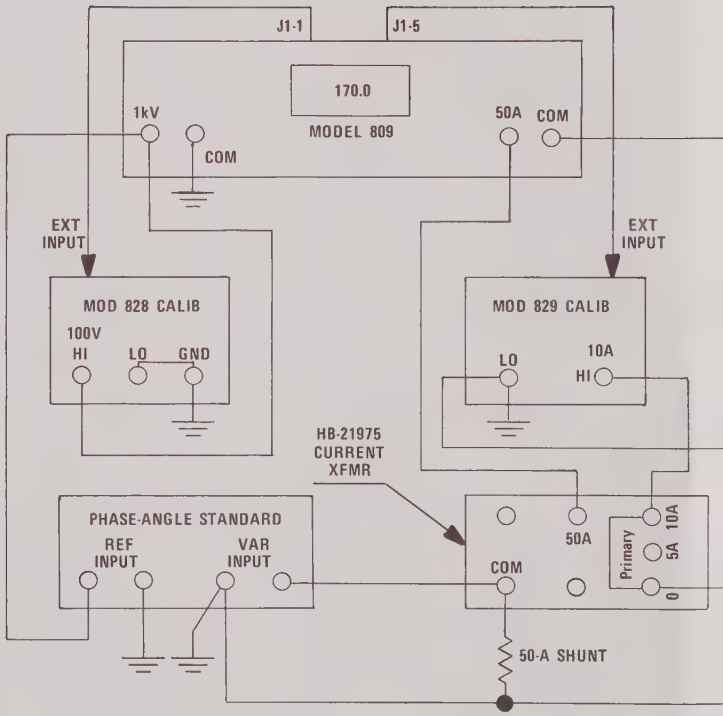


Figure 9. Test circuit for checking phase-angle accuracy.

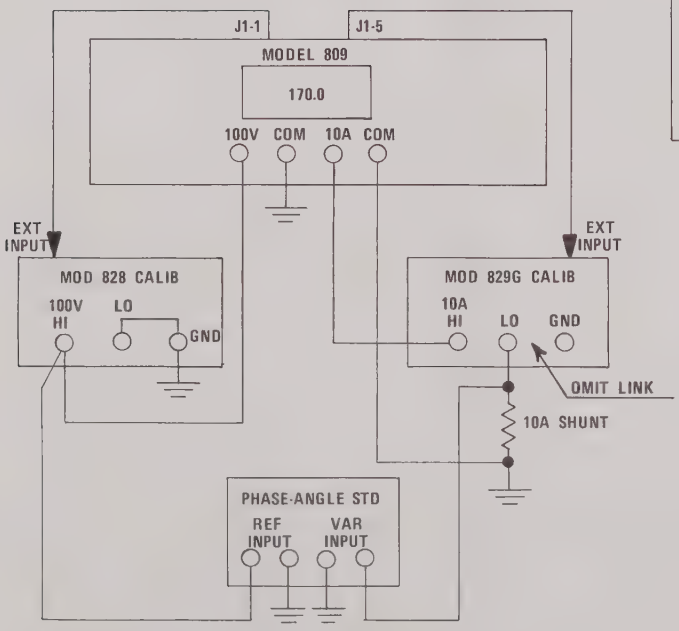


Figure 10. Test circuit for checking phase-angle accuracy.

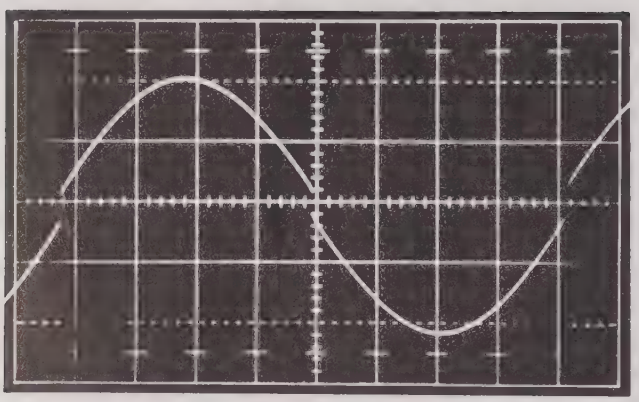


Figure 11. Typical waveform at TP3. Input current is 1 ampere.

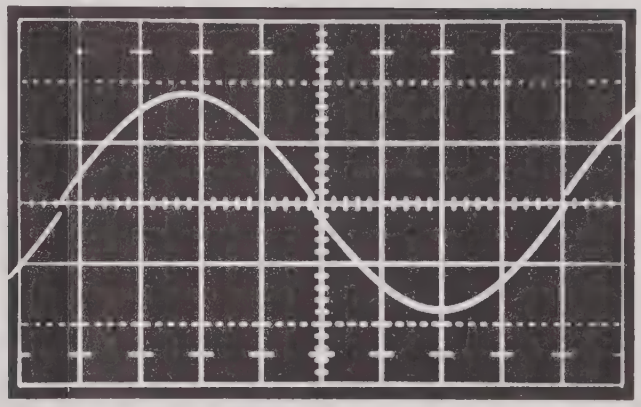


Figure 12. Typical waveform at TP5.

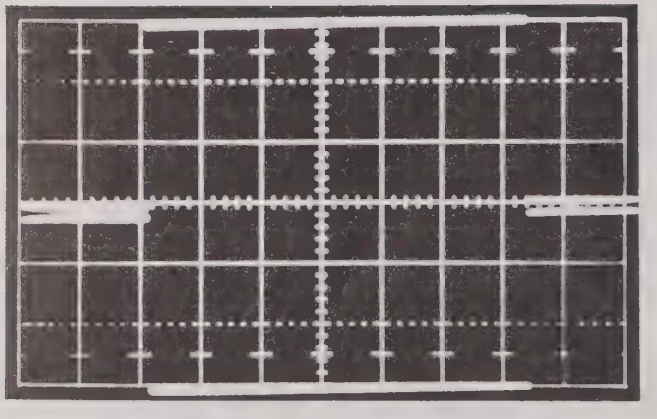
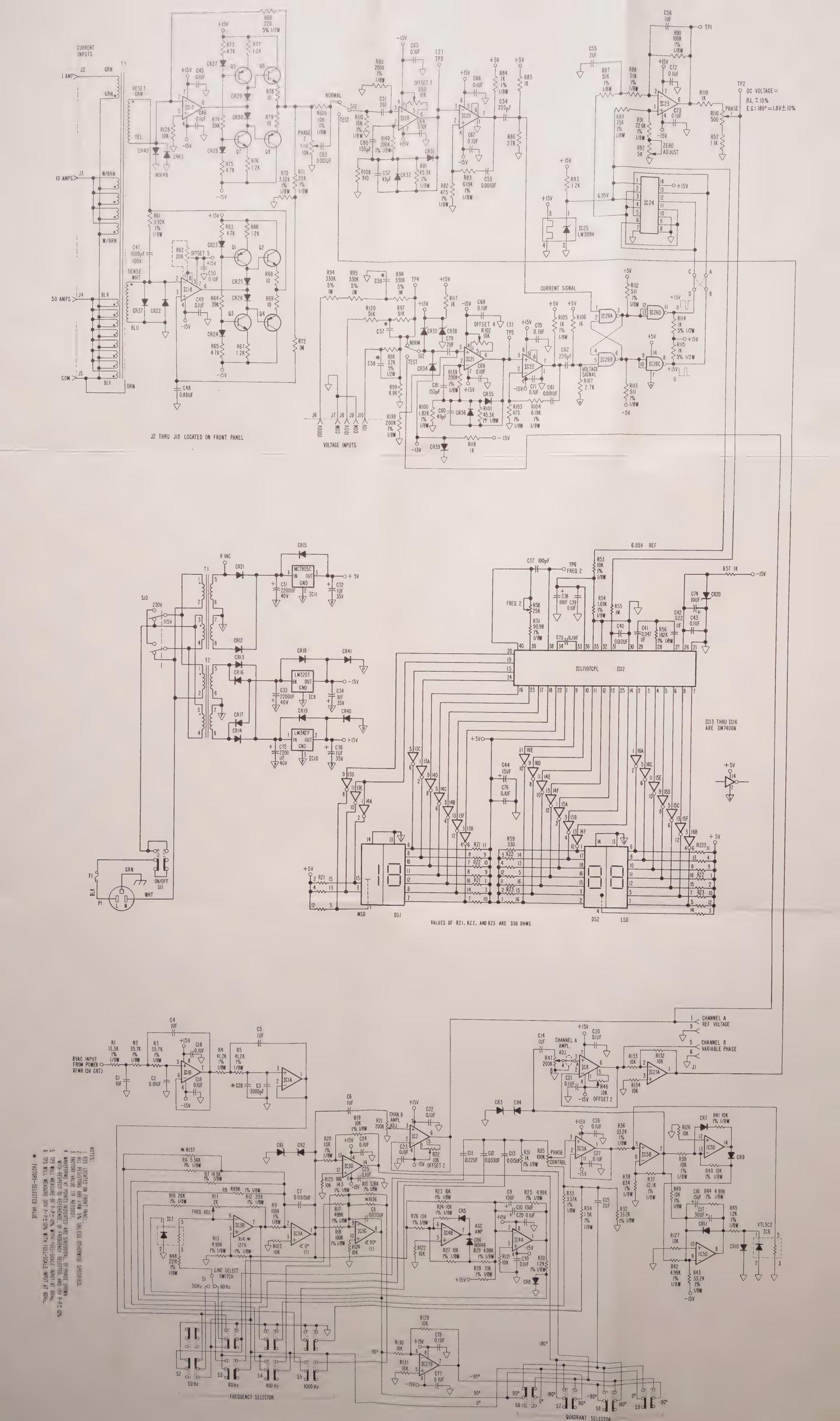


Figure 13. Typical waveform at the two outputs of the pulse-width-modulating flip-flop, IC26, as observed on a dual-trace oscilloscope. Top is the waveform at IC26-8; lower trace is IC26-11. Phase angle is 90°.


CURRENT INPUTS
1 AMP
10 AMPS
50 AMPS
COM
RESET
NORMAL
TEST
PHASE 2
OFFSET 1
OFFSET 2
OFFSET 3
OFFSET 4
OFFSET 5
ZERO ADJUST
PHASE
DC VOLTAGE = 0V ± 10% E.G: 180° = 1.8V ± 10%
CURRENT SIGNAL
VOLTAGE SIGNAL
VOLTAGE INPUTS
J2 THRU J10 LOCATED ON FRONT PANEL
6.95V REF
ICL7107CPL IC12
IC13 THRU IC16 ARE DM7406N
MSD
LSD
DS1
DS2
VALUES OF RZ1, RZ2, AND RZ3 ARE 330 OHMS
ON/OFF S11
8VAC INPUT FROM POWER XFMR (5V CKT)
CHANNEL A REF VOLTAGE
CHANNEL B VARIABLE PHASE
CHANNEL A AMPL ADJ
CHAN B AMPL ADJ
PHASE CONTROL
LINE SELECT SWITCH
FREQ ADJ
FREQUENCY SELECTOR
QUADRANT SELECTOR
NOTES:
1. RSS DESIGNATION ON FRONT PANEL.
2. ALL RESISTORS 1/8W 5% UNLESS OTHERWISE SPECIFIED.
3. FACTORY VALUE OF NETWORK.
4. WAVEFORMS AT POINTS INDICATED ARE SINUSOIDAL OF PHASE SHOWN WITH RESPECT TO REFERENCE OF FREQUENCY SELECTED, AND 4.5V P-P ± 10%
5. TP3 WILL MEASURE 5V P-P ± 10% WITH FULL-SCALE INPUT AT 60Hz.
6. TP3 WILL MEASURE 20V P-P ± 10% WITH FULL-SCALE INPUT AT 60Hz.
* FACTORY-SELECTED VALUE

MAINTENANCE and REPAIR

Maintenance of this instrument should require no more than periodic recalibration to assure its continued accuracy. Six-month intervals are suggested. Equipment may be returned to RFL for recalibration, and for repair if needed. See safety notice at beginning of this chapter.

Failure of the equipment to perform properly is usually evidence of some defect in either the procedure used or in the equipment, and it is well to determine which at the outset.

When the equipment is at fault, the nature of the failure is a most valuable symptom. An understanding of the organization of the circuits, as shown in the block diagram, will help to suggest the general area of the fault, which usually can be localized with the aid of the circuit schematic and voltage measurements. Signal tracing with an oscilloscope is also a powerful approach.

Voltage, waveform, and timing data are given in Figures 11 through 14, and on the schematic, for strategic points in the circuit. These data will aid in troubleshooting.

CIRCUIT DETAILS

PHASEMETER CIRCUIT

The phasemeter section of this instrument measures the phase difference between an input voltage and an input current. The voltage input is used as the reference.

The voltage inputs, Figure 15, are scaled with a resistive network, R94 through R99, and R120. The signal is then amplified and formed into a squarewave in IC21 and IC22.

The current input is an active transformer which provides a passive input with a dielectric strength of 1500 volts, or better.

An active current transformer degenerates the differential core flux by using a secondary circuit driven from the sense winding, through a high-gain amplifier, to null the potential across the sense winding. The result is an integrity of transfer that is orders better than that obtained when the same transformer is operated passively, and it is substantially unrelated to the size of the core.

In active transformers, it is important that the reset and sense windings operate at a low potential difference, to minimize capacitive leakage. As used here, both windings terminate at ground potential.

As shown in Figure 15, the sense winding of the current-sensing transformer, T3, connects to circuit common, and its reset winding connects to the virtual ground present at the input of IC17. The feedback circuit, using R61 and C47, is included to damp the leakage reactance of the windings. Diodes CR22 and CR37 shunt the sense winding to protect IC8 against high-level transients and spikes that may appear at the input terminals. An inter-winding shield helps to prevent common-mode injection of signals that may appear across possible ground loops.

The output of the current-transformer circuit is amplified and formed into a squarewave in IC19 and IC20.

The squarewave voltage signal appears at IC26B-5. The squarewave current signal appears at IC26A-1. These squarewaves are differentiated in C62 and C54, respectively, and they are used to edge-trigger the R-S flip-flop formed by IC26. The time during which the flip-flop stays in either state is a function of the phase angle between the squarewave voltage and current signals, as shown in Figure 14.

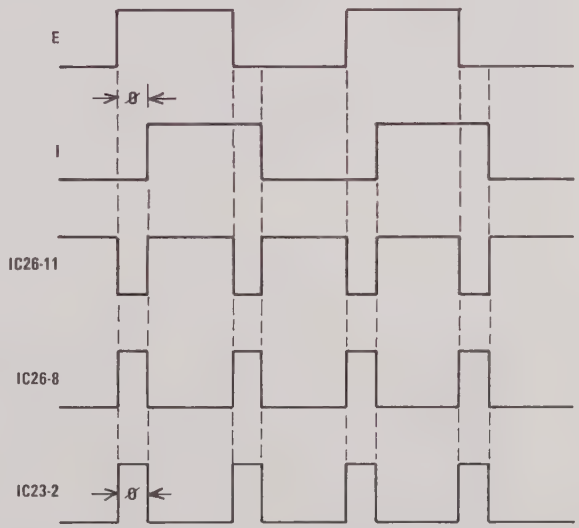


Figure 14. Timing diagram showing the relationship between the phase angle of the two input signals, the two outputs of IC26, and the input to IC23. See also Figure 13.

The output of the flip-flop is used to control the four bilateral switches contained in IC24. One of two pairs of switches connected in parallel connects the inverting input of IC23 to the voltage reference, IC25, while the other pair of switches connects it to ground. The flip-flop, therefore, pulse-width modulates the reference voltage. The pulse-width-modulated signal is then filtered, level-shifted by adjusting the voltage on IC23-3, and scaled to provide a signal of approximately 0 to ±1.8 Vdc to a 3-½-decade A/D converter and display which uses IC12 through IC16. The phase display is an LED type, and it displays phase angle from 000.0 to ±180.0°.

The normal position for the two jumpers at the output of the flip-flop formed by IC26 is A-B and C-D. The sign of the display may be reversed by moving them to A-D and C-B.

PHASE-GENERATOR CIRCUIT

When the Model 809 is used as a phase generator, it is connected in a circuit such as that suggested in Figure 4, and the phasemeter section then monitors the phase of the input signals to the device under test.

The oscillator section of the phase generator is a state-variable oscillator, IC3, Figure 15. Its output level is controlled with an automatic-gain-control (AGC) loop using both sections of IC4 and IC7 to stabilize its amplitude.

The oscillator circuit is reconnected to form a bandpass filter when it is desired to have an output that is synchronized with the powerline, either 50 or 60 Hz. This occurs automatically when S1 is set to the same frequency as the front-panel, frequency-selector pushbutton. A 5-pole Chebyshev, lowpass filter, IC1, provides a distortion-free signal from the powerline. The state-variable filter provides additional filtering, along with its normal function of providing four different output signals with phase angles of 0, 90, 180, and 270°.

When Quadrant 1 is selected, phases 0 and 90° are connected to a ten-turn potentiometer, R35, which is the phase control. The position of the wiper is linearly related to phase, but the amplitude is not constant with respect to the wiper's position. An AGC circuit, using IC5 and IC6, therefore, is used to hold the output level constant. This voltage is subsequently amplified in IC8 and fed out at the variable phase on J1-5. Its stabilized output amplitude is set with R47.

Operation for outputs for Quadrants 2, 3, and 4 is identical except that phase 90°, 180°, and -90° are selected with the quadrant selector, as marked on Figure 15.

The 0° phase, used as the reference, is of constant amplitude. It is amplified in IC2 and fed out to J1-1. Its stabilized amplitude is adjusted with R21.

POWER SUPPLY

The power supply, shown in Figure 15, is of conventional design. Transformers with split primaries connected in either series or parallel provide for the two ranges of input voltage. One transformer powers plus and minus regulated 15-volt outputs for operation of opamps and CMOS circuits. A second transformer energizes a regulated 5-volt output for operating TTL logic circuits.

TABLE OF REPLACEABLE PARTS

Circuit Symbol	Description	RFL Part Number
	Model 809 Phase Generator/Meter, Assembly HB-95700	
C1, 4, 5, 6, 14, 56	Capacitor, metallized polycarbonate 1μF, 2%, 100V Wesco 32 MPC, or eq.	H-1007-966
C2	Capacitor, metallized polycarbonate, 0.01μF, 2%, 200V, Wesco 32 MPC, or eq.	H-1007-1115
C3	Capacitor, polystyrene, 0.0033μF, 2%, 100V, Wesco 32P, or eq.	H-5115-11
C7, 8	Capacitor, metallized polycarbonate, 0.0315μF, 2%, 200V, Wesco 32 MPC, or eq.	H-1007-1188
C9, 10	Capacitor, tantalum, 15μF, 20%, 35V, Corning CCZ-035-156-20, or eq.	H-1007-654
C11	Capacitor, metallized polycarbonate, 0.22μF, 2%, 50V, Wesco 32 MPC, or eq.	H-1007-1329
C12	Capacitor, metallized polycarbonate, 0.033μF, 2%, 100V, Wesco 32 MPC, or eq.	H-1007-1328
C13	Capacitor, metallized polycarbonate 0.015μF, 2%, 200V Siemens Type MKH, or eq.	H-1007-1123
C15, 51 55, 79	Capacitor, metallized polycarbonate, 2μF, 2%, 50V, Wesco 32 MPC, or eq.	H-1007-1361
C16, 44	Capacitor, tantalum, 15μF, 20%, 20V, Kemet T322D156M020AS, or eq.	H-1007-716
C17	Capacitor, tantalum, 33μF, 10%, 20V, Kemet T310C336K020AS, or eq.	H-1007-676
C18-27,29, 30, 39, 43, 45, 46, 49, 50, 64-73, 75-78	Capacitor, ceramic, 0.1μF, 50V, Kemet C320C104PU5EA, or eq.	H-1007-1366
C28	Capacitor, polystyrene, factory-selected value, Wesco 32P, or eq.	H-5115-(XX)
C31, 33, 35	Capacitor, electrolytic, 2200μF, -10 +50%, 40V, Stettner-Trush EG2T/40, or eq.	H-1007-1172
C32, 34, 36	Capacitor, tantalum, 1μF, 10%, 35V, Kemet T110A105K035AS, or eq.	H-1007-1156
C37	Capacitor, dipped mica, 100pF, 10%, 100V Electro Motive DM10, or eq.	H-1080-328
C38, 74	Capacitor, tantalum, 10μF, 10%, 20V, Kemet T322C106K020AS, or eq.	H-1007-955
C40	Capacitor, polystyrene, 0.012μF, 2%, 100V, Wesco 32P, or eq.	H-5115-39
C41	Capacitor, polystyrene, 0.047μF, 2%, 100V, Wesco 32P, or eq.	H-5115-67
C42	Capacitor, polypropolene, 0.22μF, 2%, 100V F-Dyne PPA-11, or eq.	H-0105-84
C47	Capacitor, dipped mica, 0.001μF, 5%, 100V, Electro Motive DM19, or eq.	H-1080-395
C48	Capacitor, mylar, 0.49μF, 2%, 100V, Wesco 32M, or eq.	H-1007-449
C52, 60	Capacitor, dipped mica, 49pF, 5%, 100V, Electro Motive DM-15, or eq.	H-1080-359
C53, 61	Capacitor, ceramic, 0.001μF, 10%, 200V, Kemet C320C102K2R5EA, or eq.	H-1007-1388
C54, 62	Capacitor, dipped mica, 220pF, 5%, 100V, Electro Motive DM10, or eq.	H-1080-393

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
C57, 58, 59	Capacitor, dipped mica, factory-selected value	H-1080-(XX)
C63	Capacitor, ceramic, 0.001μF, 10%, 100V, Kemet CK128BX102-K, or eq.	H-1007-1360
C80, 81	Capacitor, dipped mica, 155pF, 2%, 500V, Electro Motive DM-19, or eq.	HA-16609
CR1-4	Diode, zener, 7.5V, 5%, Type 1N4737A,	HA-34410
CR5-11, 22-37 42, 43	Diode, silicon, Type 1N914B/1N4448	HA-26482
CR12-19, 21, 22, 40, 41	Diode, silicon, Type 1N4003	HA-30769
CR20	Diode, zener, 5.1V, 5%, 1W, Type 1N4733A	HA-29759
CR38, 39	Diode, zener, 14V, 0.5W, Type 1N5244B	HA-41075
DS1	Display, MAN 6650-F	HA-91958
DS2	Display MAN 6640-F	HA-91957
F1	Fuse, 0.25A, 250V, slo-blo, Size 3AG	HA-17166
IC1, 4, 27	Dual linear opamp, Tex. Inst. TL082CP, or eq.	H-0620-155
IC2, 8	Linear opamp, Tex. Inst. TL081CP, or eq.	H-0620-160
IC3, 5	Quad linear opamp., Tex. Inst. TL084CN, or eq.	H-0620-151
IC6	Photo-coupled resistor, Vactec VTL5C2, or eq.	HA-95047
IC7	Photo-coupled resistor, Vactec VTL5C3, or eq.	HA-94288
IC9	Linear voltage regulator, -15V, National LM320T-15, or eq.	H-0620-177
IC10	Linear voltage regulator, 15V, Motorola MC7815CP, or eq.	H-0620-82
IC11	Linear voltage regulator, 5V, Motorola MC7812CP, or eq.	H-0620-77
IC12	A/D converter, 3-½ digit, Intersil ICL7107CPL, or eq.	H-0625-4
IC13-16	TTL Hex Inverter/Buffer, Tex. Inst. SN7406N, or eq.	H-0610-46
IC17, 18	Linear opamp., National LF355N, or eq.	H-0620-139
IC19, 21, 23	Linear opamp. RCA CA3140AE, or eq.	H-0620-193
IC20, 22	Voltage comparator, National LM311N, or eq.	H-0620-188
IC24	Quad, bilateral switch, Fairchild F4066PC, only	H-0615-65
IC25	Voltage reference, National LM399H, or eq.	H-0620-172
IC26	TTL Quad 2-input NAND gate, National DM7426N, or eq.	H-0610-84
Q1, 4, 5, 8	Transistor, silicon, PNP, Type 2N2907A	HA-37439
Q2, 3, 6, 7	Transistor, silicon, NPN, Type 2N2222A	HA-37445
R1-10, 12-20, 23-34, 36-45, 48, 49, 51 53, 54, 56 61, 70, 71 80-84, 87-91, 100-106, 109, 110, 112, 113, 128-134, 138-140	Resistor, metal-film, 1%, 0.125W, value on schematic, Type RN55D, RFL Spec HA-38301	H-1510-(XXX)

CIRCUIT SYMBOL	DESCRIPTION	PART NUMBER
R11	Resistor, variable, metal-film, 2K, 10%, 0.5W, Helipot 68WR2K, or eq.	HA-90392
R21, 47	Resistor, variable, metal-film, 200K, 10%, 0.5W, Bourns 3299X-1-204	HA-44562
R22, 46, 50, 102, 111	Resistor, variable, metal-film, 10K, 10%, 0.5W, Helipot 68WR10K, or eq.	HA-48548
R35	Resistor, variable, wirewound, 100K, 5%, 2W, Duncan 3253, or eq.	HA-33290
R52, 55, 59, 63-69, 72-79, 86 93, 107, 108, 121-127	Resistor, fixed, composition, 5%, 0.25W, value on schematic, Allen Bradley CB, or eq.	H-1009-(XXX)
R57, 85, 114-117, 119	Resistor, metal-film, 1K, 1%, 0.25W, Type RN¼, RFL Spec P30113	H-1510-577
R58	Resistor, variable, metal-film, 25K, 10%, 0.5W, Helipot 68WR25K, or eq.	HA-90393
R60, 97, 98, 99, 114, 115, 120	Resistor, fixed, composition, 5%, 0.5W, value on schematic, Allen Bradley EB, or eq.	H-1009-(XXX)
R62	Resistor, variable, metal-film, 20K, 10%, 0.5W, Helipot 68WR20K, or eq.	HA-44529
R92	Resistor, variable, metal-film, 5K, 10%, 0.5W, Helipot 68WR5K, or eq.	HA-43102
R94, 95, 96	Resistor, fixed, composition 330K, 5%, 1W, Allen Bradley GB, or eq.	H-1009-257
R118, 135	Not used	———
R116	Resistor, variable, metal-film, 500 ohms, 10%, 0.5W, Helipot 68WR500K, or eq.	HA-94296
RZ1, 2, 3	Resistor network, cermet, 330 ohms, 2w/pkg., Beckman 898-3-R330.,or eq	HA-44532
T1	Transformer, power, Signal DPC-16-640, or eq.	HA-44538
T2	Transformer, power, Signal DPC-34-700, or eq.	HA-36124
T3	Transformer, current-signal input	HB-95749
-----	Schematic (Figure 15)	H-95704
	Cable interconnect 809/828	96254
	Cable interconnect 809/829G	96255

CERTIFICATE
FOR
MODEL 809
PHASE GENERATOR METER

Serial Number 113

The described instrument was calibrated at RFL Industries, Inc., Boonton, N.J. on 4/14 at an ambient room temperature of 23 °C. Calibration test covered all ranges provided by the instrument. Instrumentation used in calibration have calibration accuracy traceable to the National Bureau of Standards either directly or indirectly in an unbroken chain.

Certified by R Wegrzick

Date 7-14-1986

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